Dust on Mars

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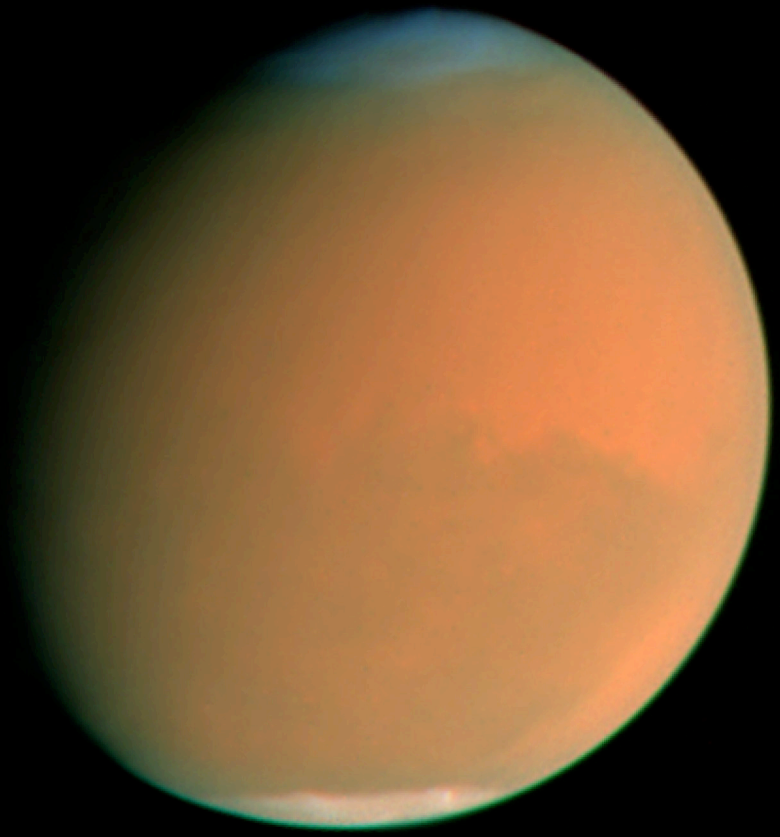
Dust on the Moon and Mars?

1. What can we learn about Mars dust on the Moon?
2. Physical, chemical & biological properties of Mars dust
3. Future measurement needs

On the Moon and Mars the source of soil is comminuted basaltic rock

On Mars this has been further altered by:
-Atmosphere & wind
-Ice, water, & brines
-Oxidation
-Volcanic gases
- Life?

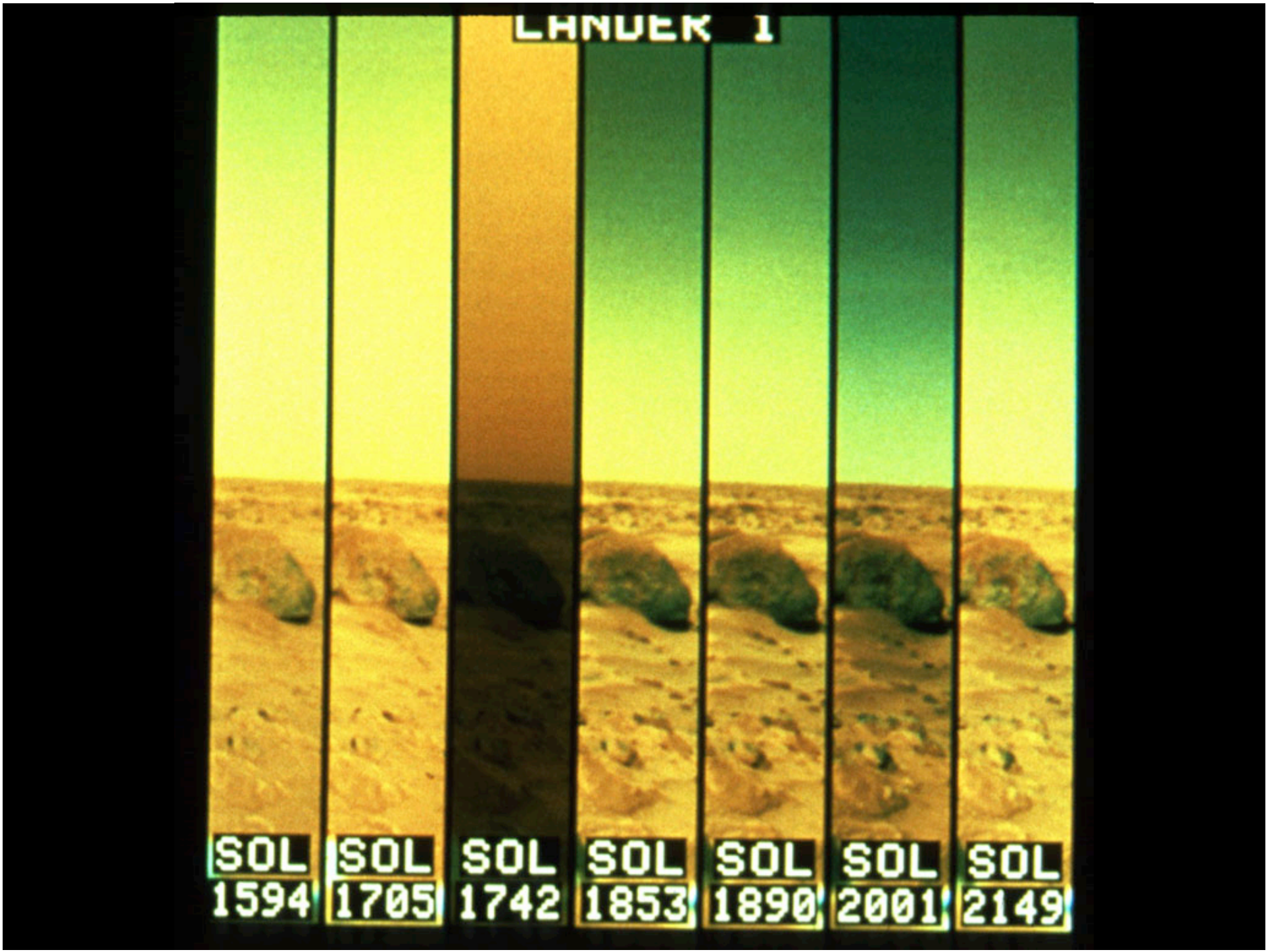
June 26, 2001

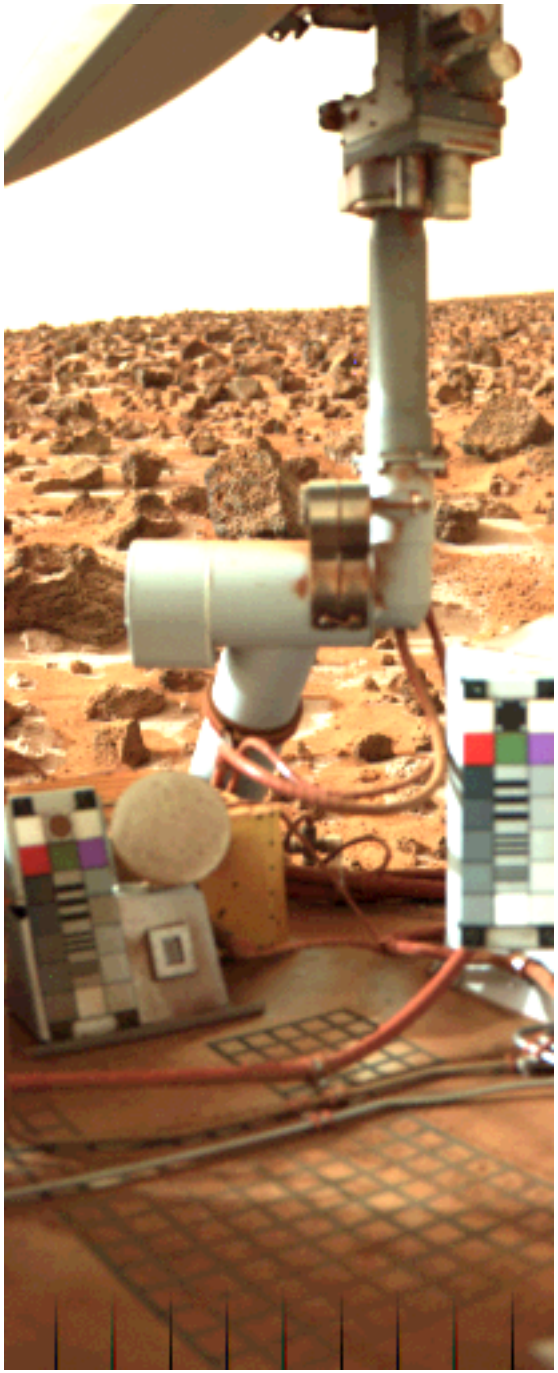


September 4, 2001

Mars • Global Dust Storm
Hubble Space Telescope • WFPC2

NASA, J. Bell (Cornell University), M. Wolff (SSI), and the Hubble Heritage Team (STScI/AURA) • STScI-PRC01-31

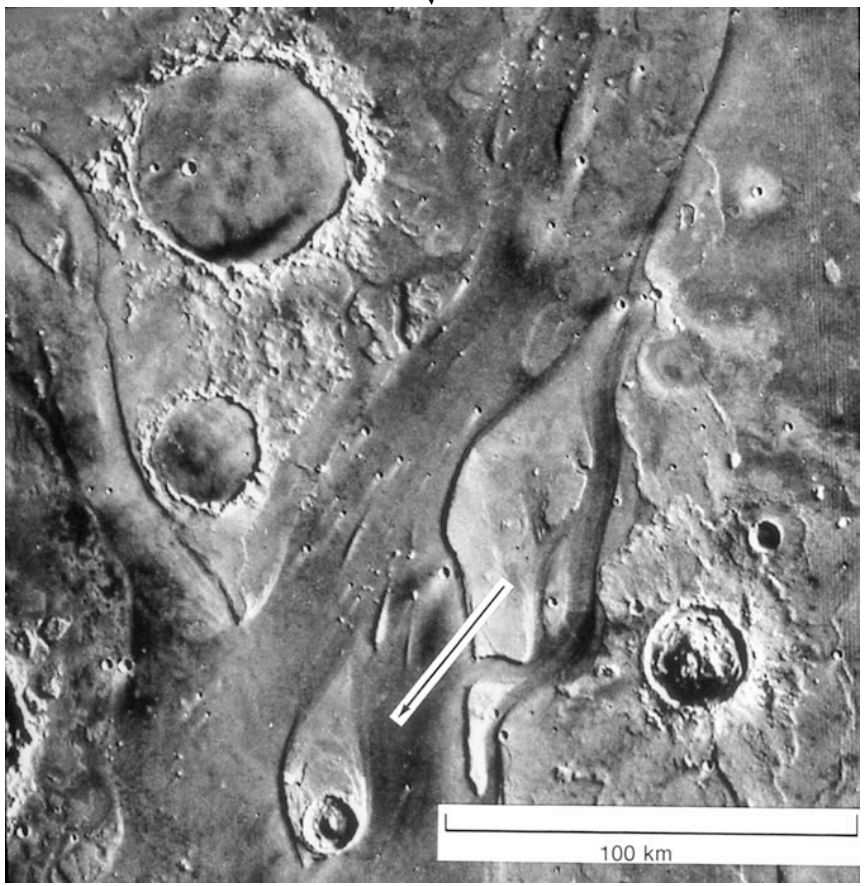

LANDER 1
SOL 1594
SOL 1705
SOL 1742
SOL 1853
SOL 1890
SOL 2001
SOL 2149

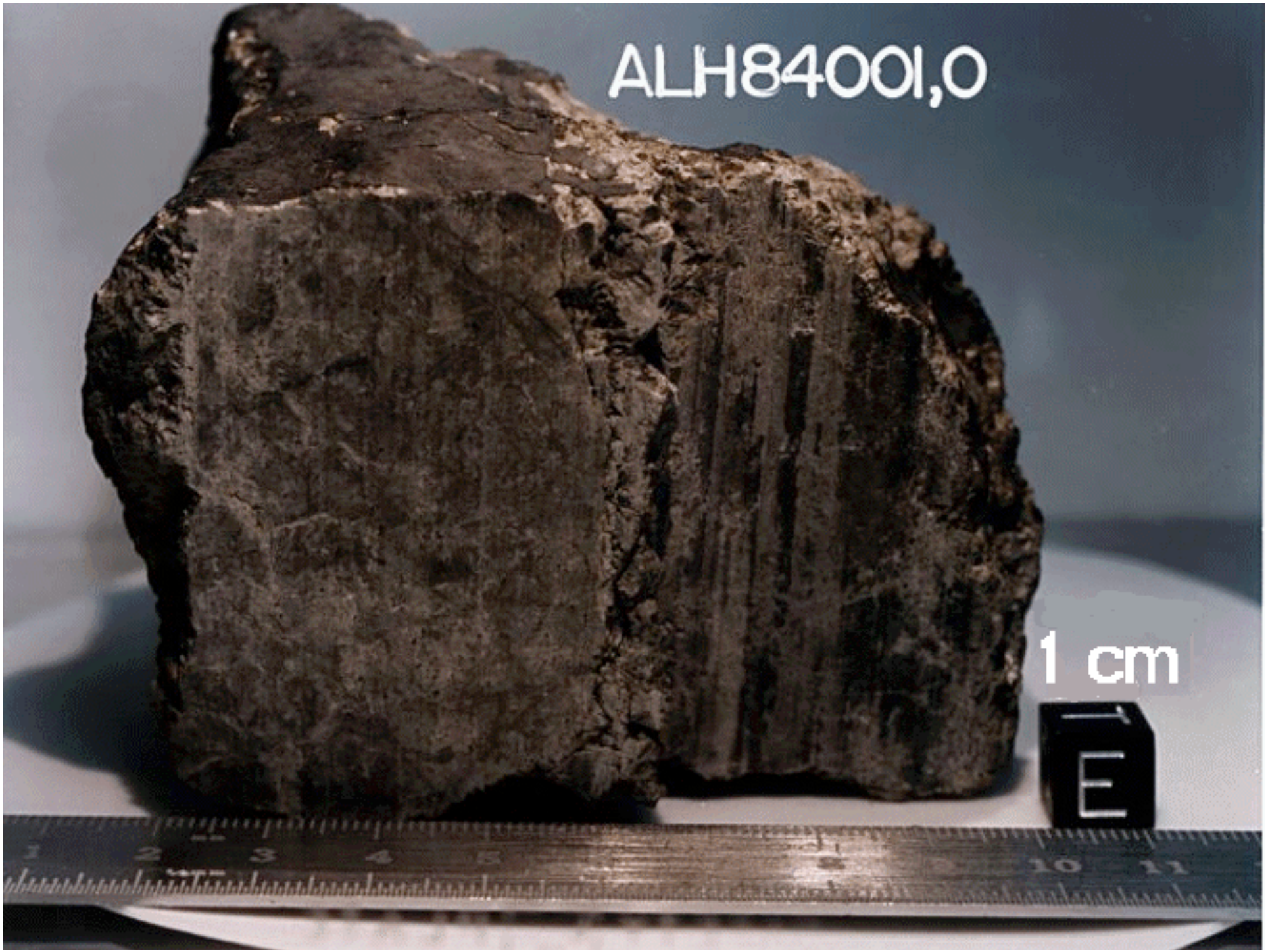


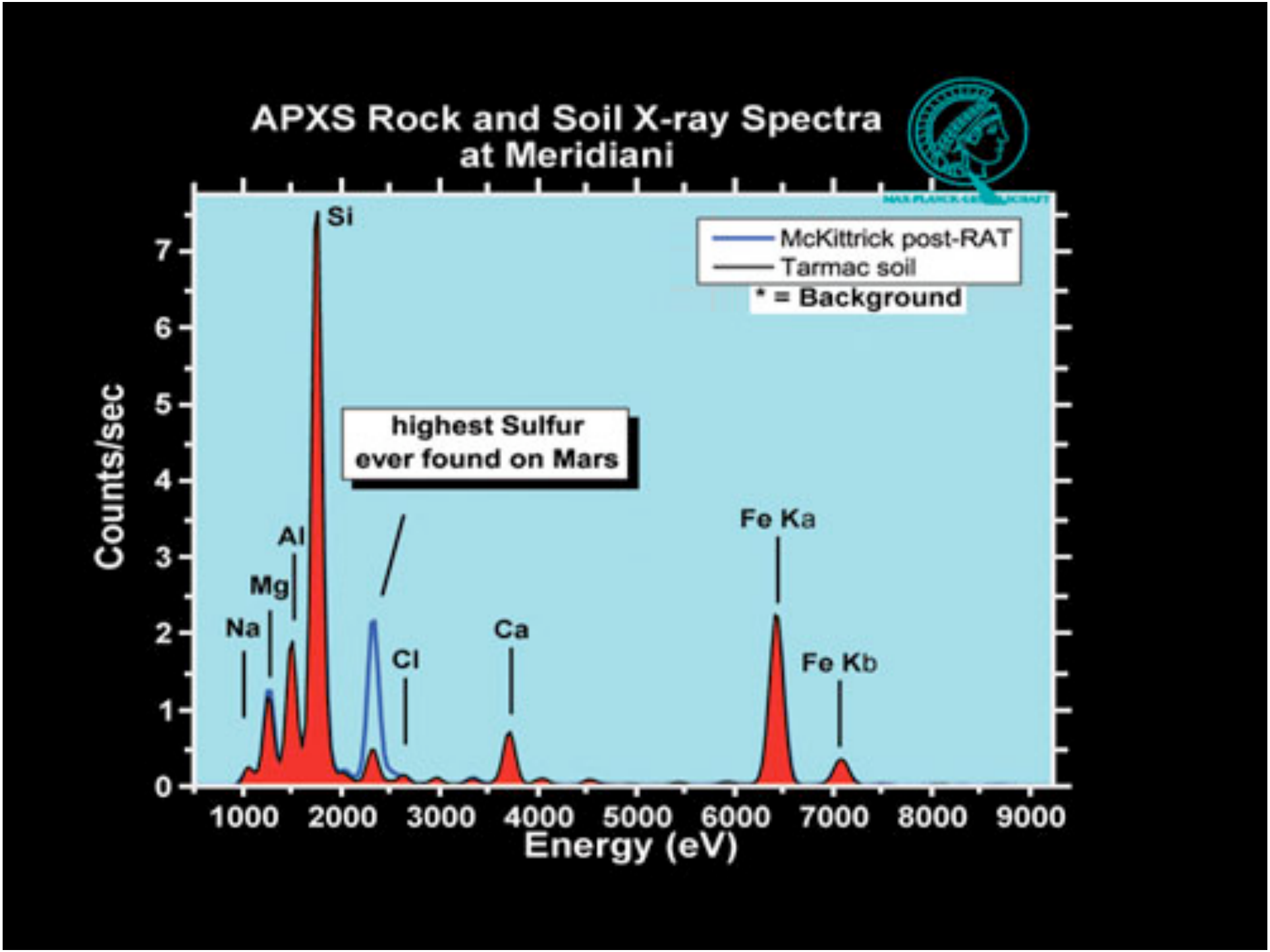
Viking:

water frost on Mars

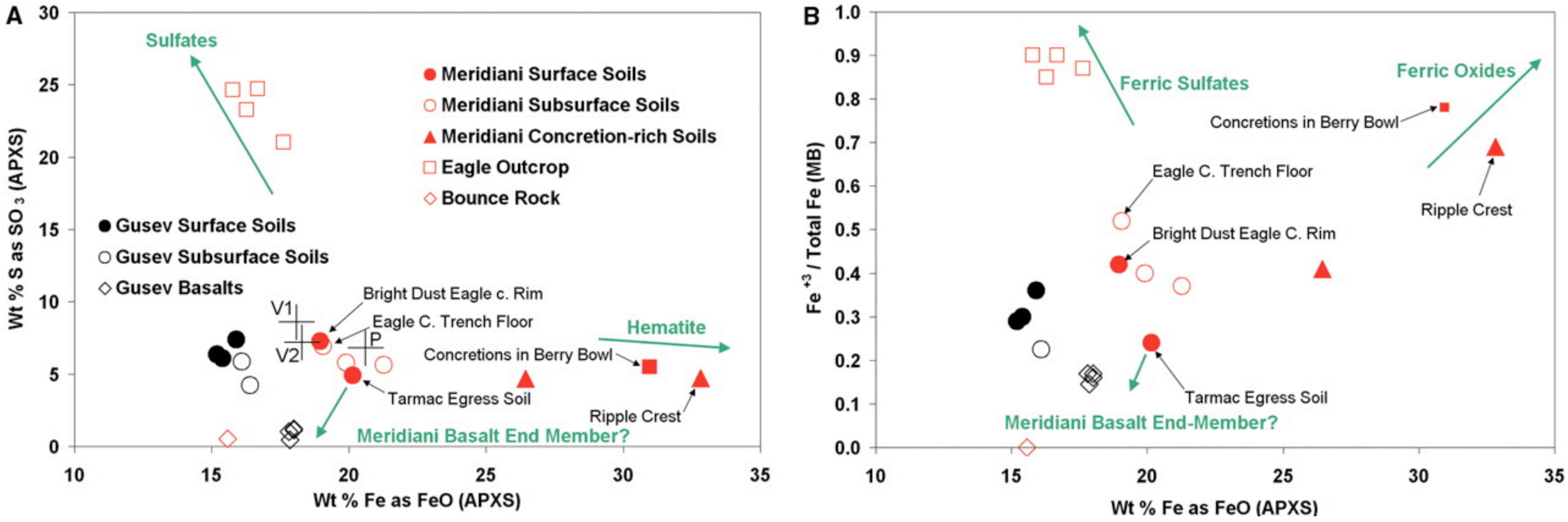
water flowed on the surface




ALH84001,0
1 cm
E


APXS Rock and Soil X-ray Spectra
at Meridiani
McKittrick post-RAT
Tarmac soil
* = Background
highest Sulfur
ever found on Mars
Si
Al
Mg
Na
Cl
Ca
Fe Ka
Fe Kb
Counts/sec
0
1
2
3
4
5
6
7
1000
2000
3000
4000
5000
6000
7000
8000
9000
Energy (eV)

The soils at the two Viking lander sites, Pathfinder, and the two MER sites are similar in composition.

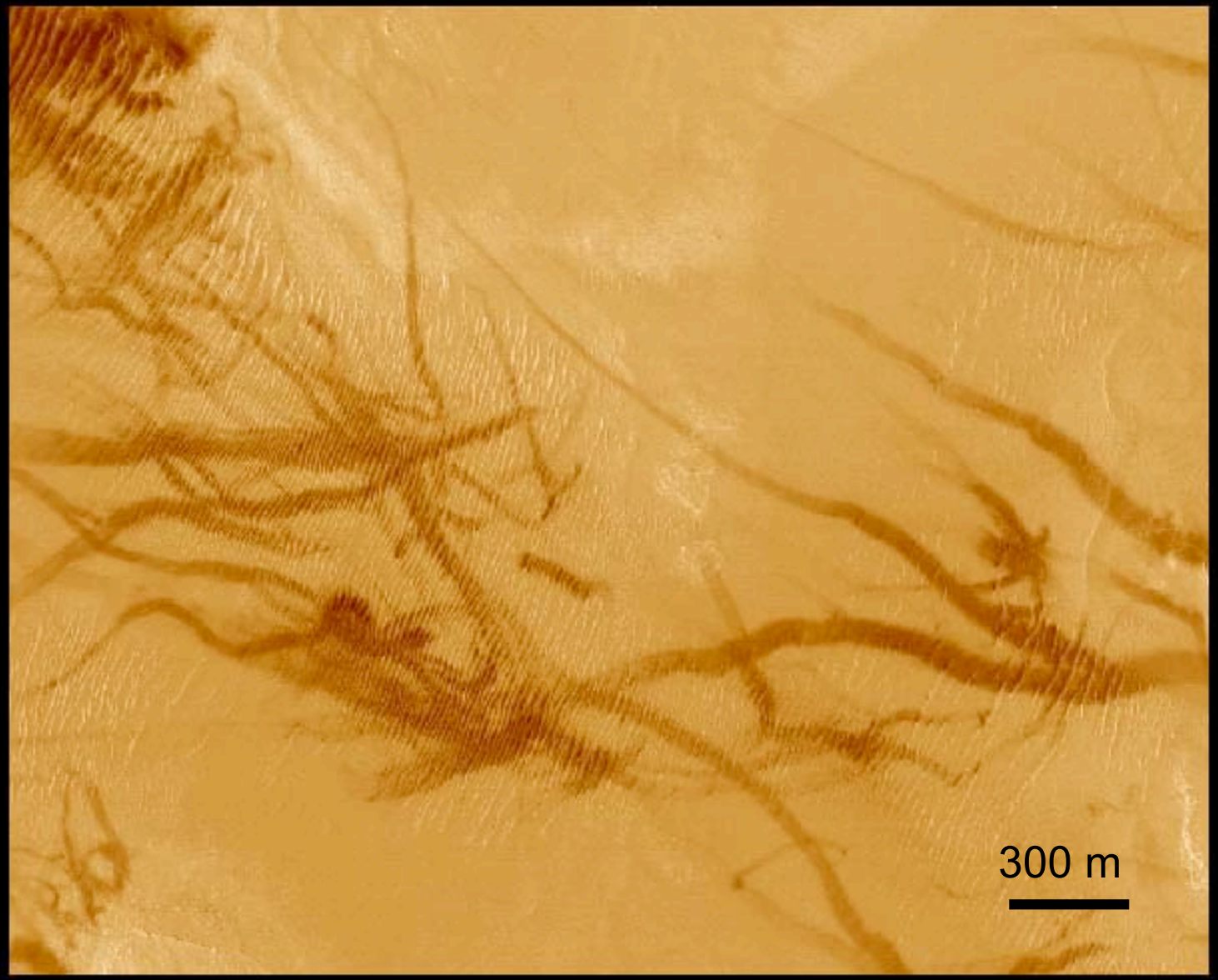


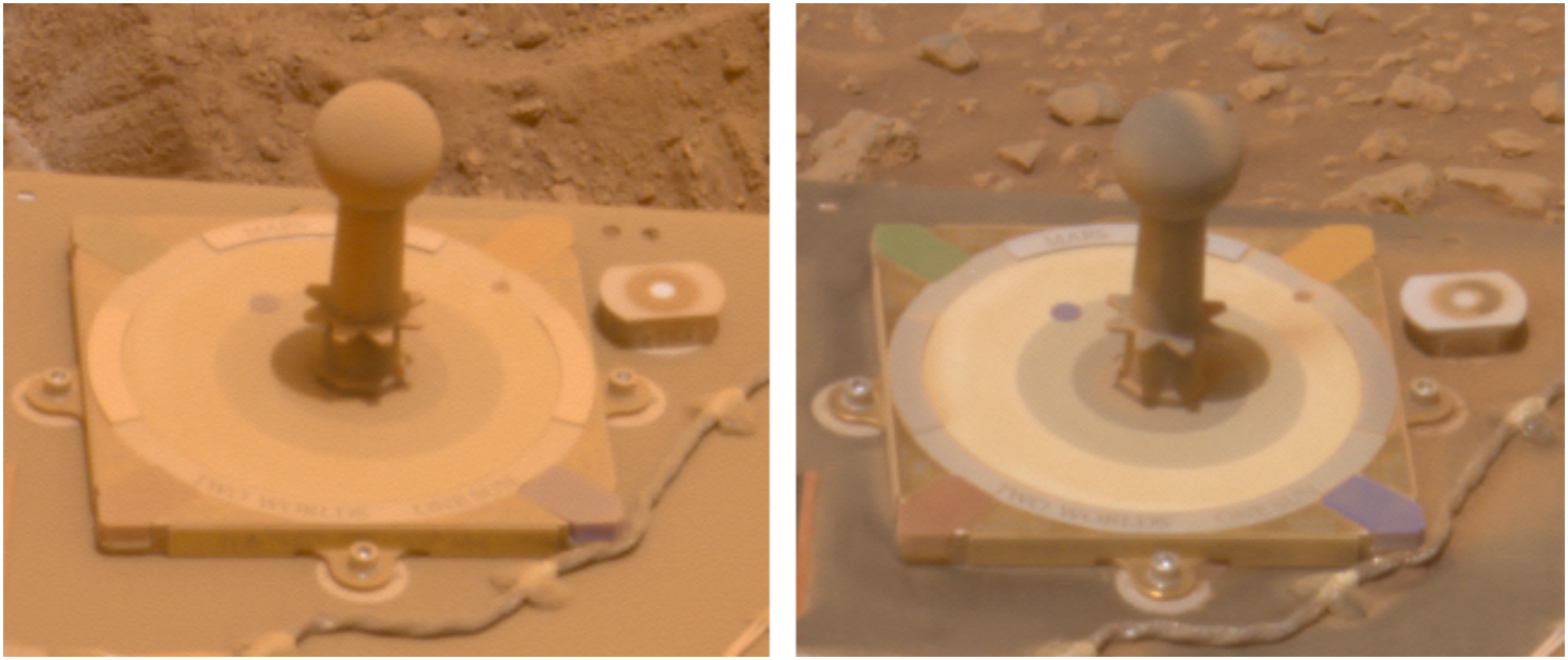
Soderblom et al. *Science* 2005

Physical properties of Martian dust

- No direct data for sizes < 100 microns
- Dust on Mars is likely to be physically weathered due to wind transport, i.e. shards or long thin slivers of particles are unlikely.
- Other than the presence of oxidants and the absence of organics, the martian soil is not unusual. No reason to expect toxic metals etc.

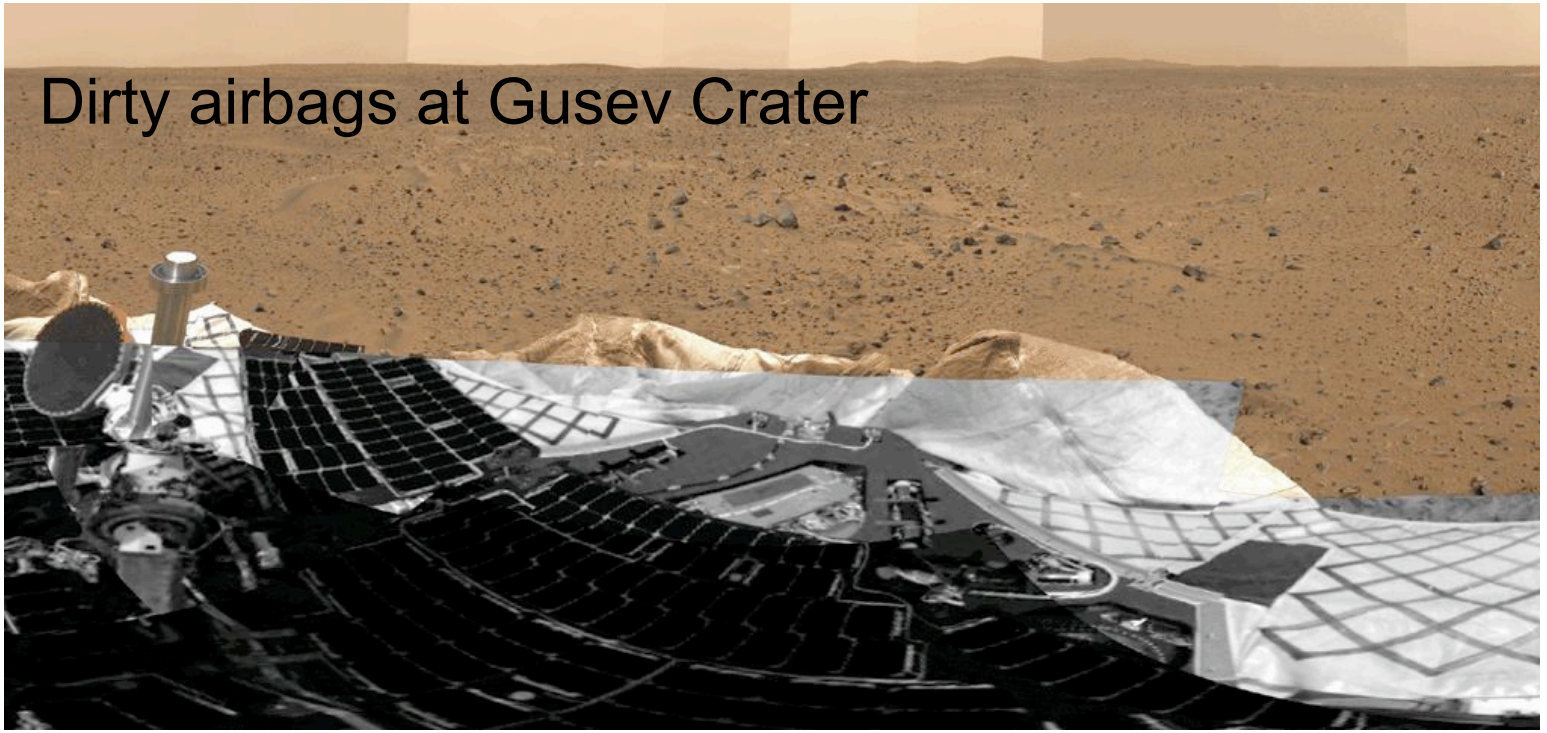
Dust devil tracks on Mars



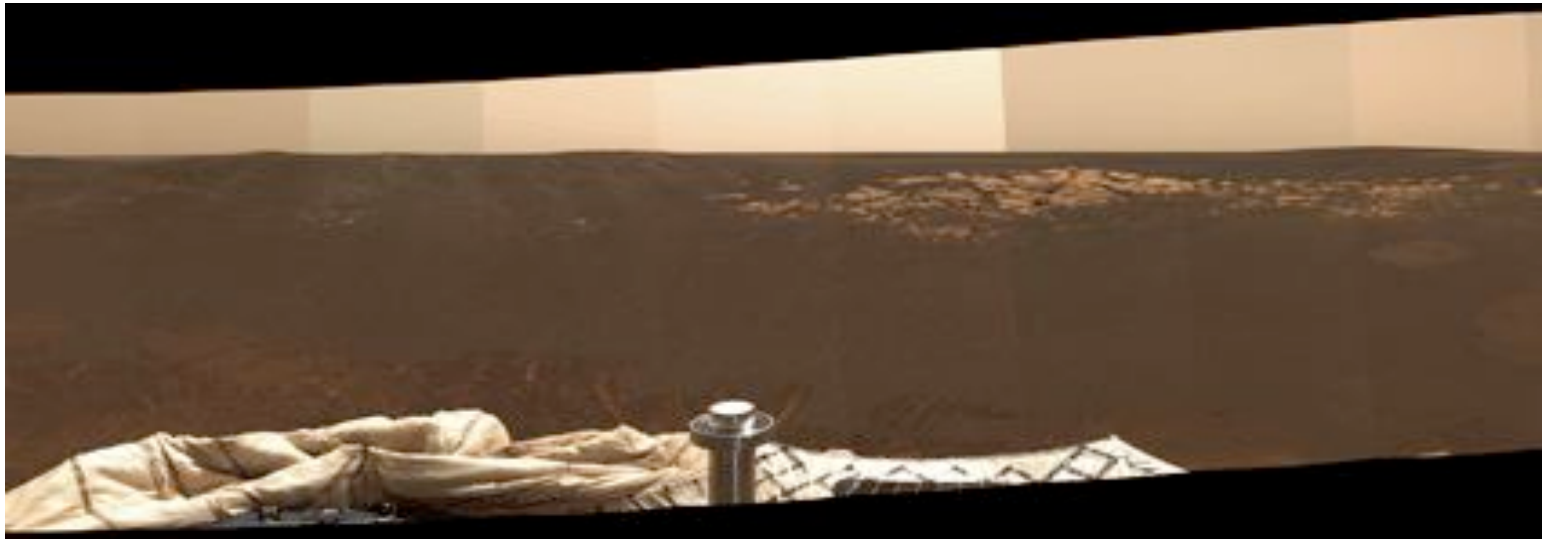


Before and After a “cleaning” event on Spirit
March 2005

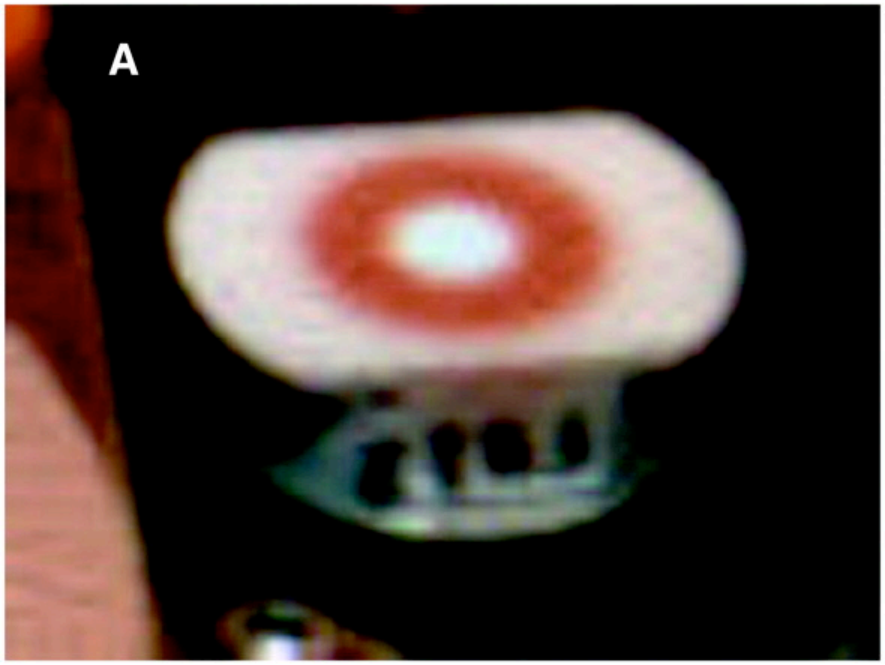
Dirty airbags at Gusev Crater

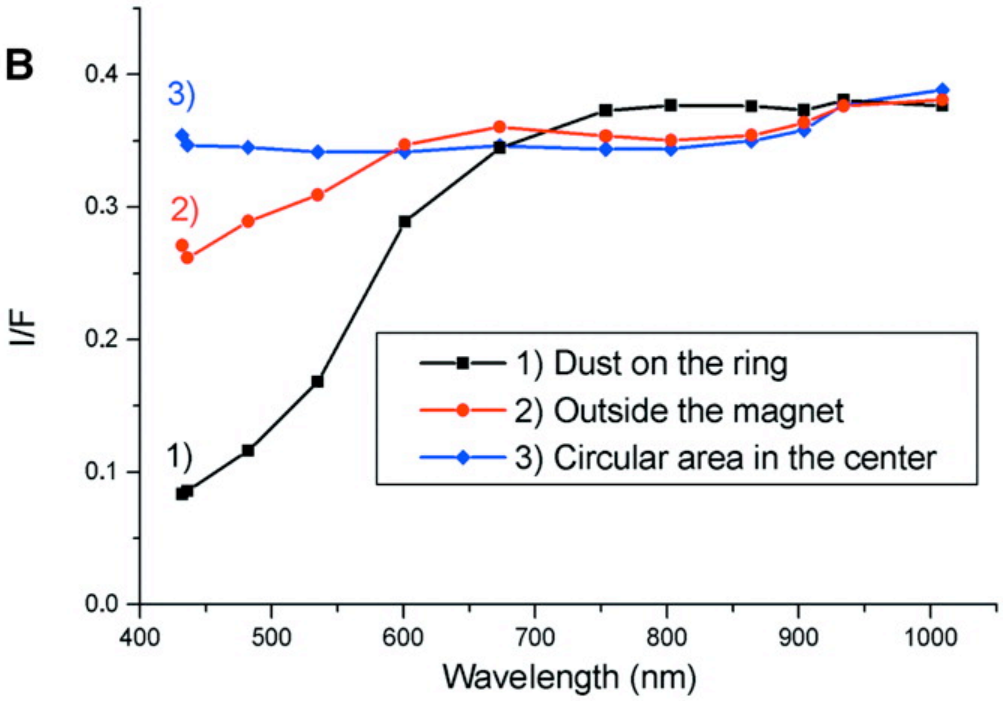


Clean airbags at Eagle Crater



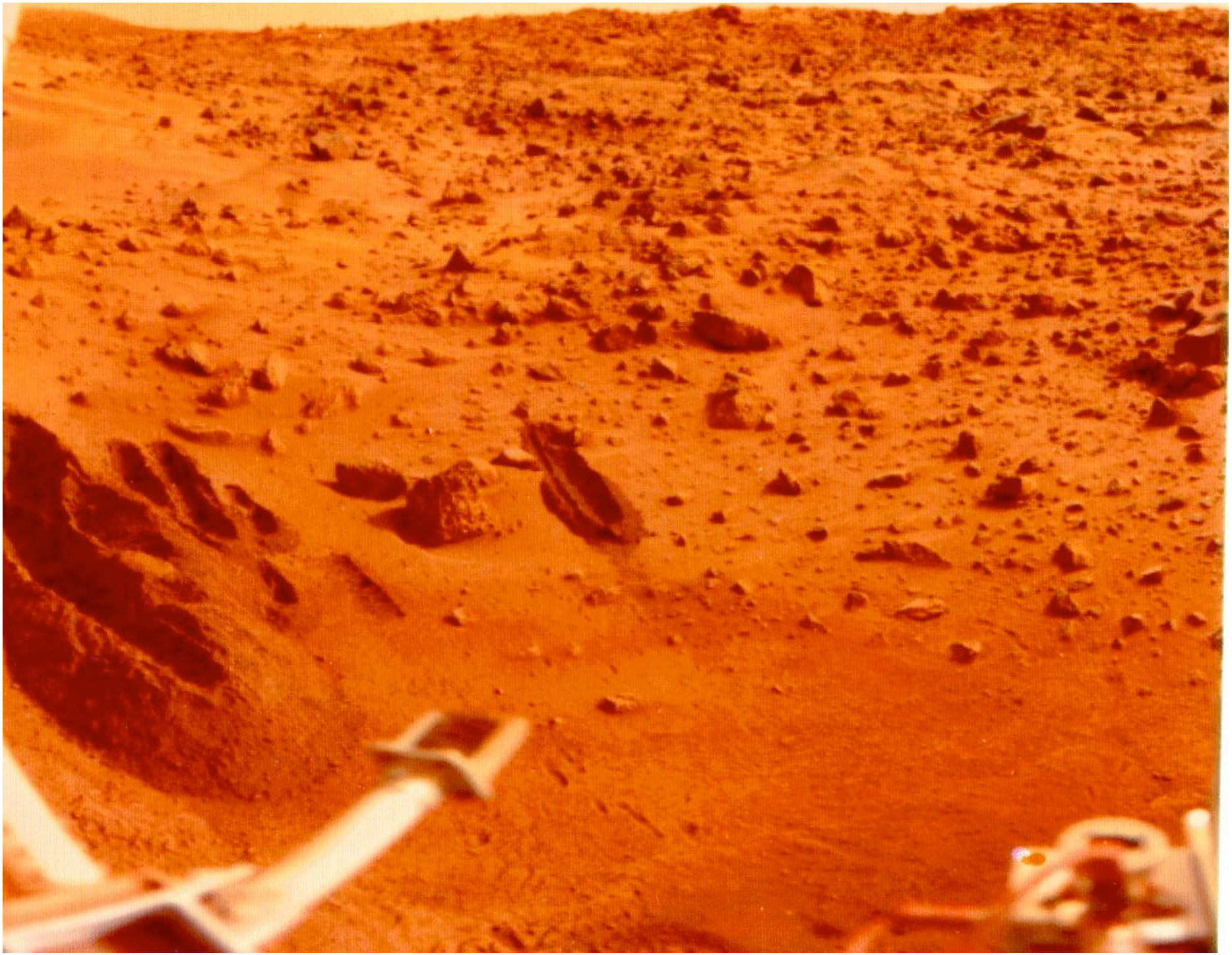
Virtually all martian airborne dust is magnetic and an area can be kept clear with magnetic fields.



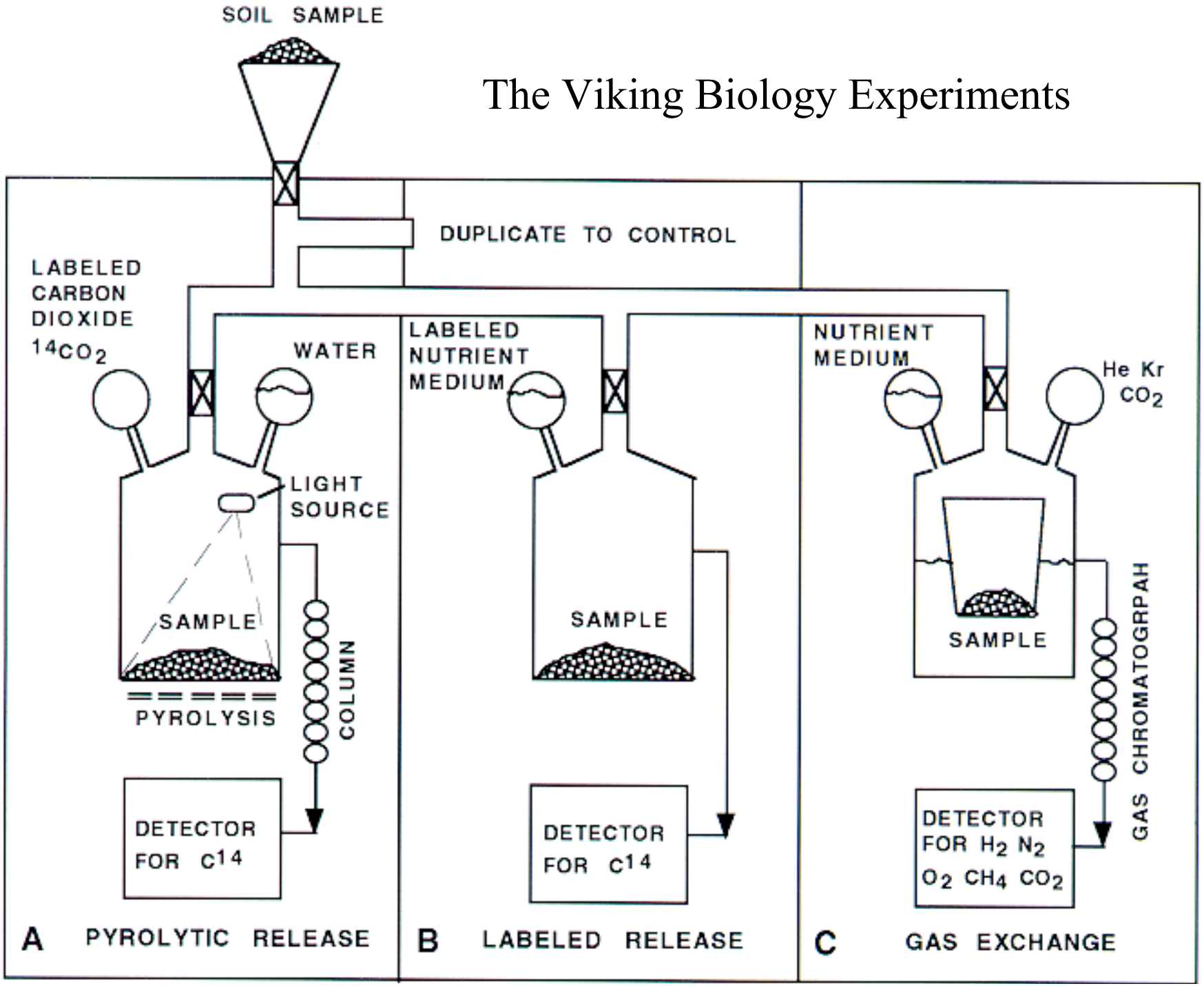


The “sweep” magnet:

1. Ring of dust is magnetic particles
2. Outside the ring is all particles (no magnetic field)
3. Center area is non-magnetic particles



The Viking Biology Experiments



Viking results indicate soil reactivity

- O_2 released upon humidification (GEx)
- CO_2 released from organics (LR)
- No organics detected in the soil (GCMS)

Oxidant levels indicated by Viking

Location	GEx ($KO_2 \rightarrow O_2$)	LR($H_2O_2 \rightarrow O_2$)
Viking 1 (surface)	35 ppm/m	1ppm/m
Viking 2 (surface)	10	1
Viking 2 (sub-rock)	3	1

Gas Exchange Experiment (GEx)

1. O_2 was released on humidification
2. Reactivity was unaltered by heating
3. Concentration varies: 3-35 ppm/m

Sample	GEx O_2 (nmoles cm^{-3})	Oxidant ($KO_2 \rightarrow O_2$)
Viking 1 surface	770	35 ppm/m
Viking 2 surface	194	10
Viking 2 sub-rock	70	3

Labeled Release (LR)

1. CO_2 was released from organics
2. Reactivity was effected by heating
   -eliminated by 160°C for 3 hours
   --eliminated by 50°C for 3 hours
   -reduced 70% by 46°C for 3 hours
   -eliminated by 141 days at 10°C
3. Release constant, possibly only formate consumed

Sample	LR CO_2 (nmoles cm^{-3})	Oxidant ($H_2O_2 \rightarrow O$)
Viking 1 surface	~30	1 ppm/m
Viking 2 surface	~30	1
Viking 2 sub-rock	~30	1

Suggested Explanation: Three different oxidants (Klein 1978, 1979)

1. A strong thermally stable oxidant
   eg. KO_2, ZnO_2, CaO_2 at 3-35 ppm/m
2. A strong thermally labile oxidant
   eg. H_2O_2 at 1 ppm/m
3. A weak oxidant
   γ-Fe_2O_3

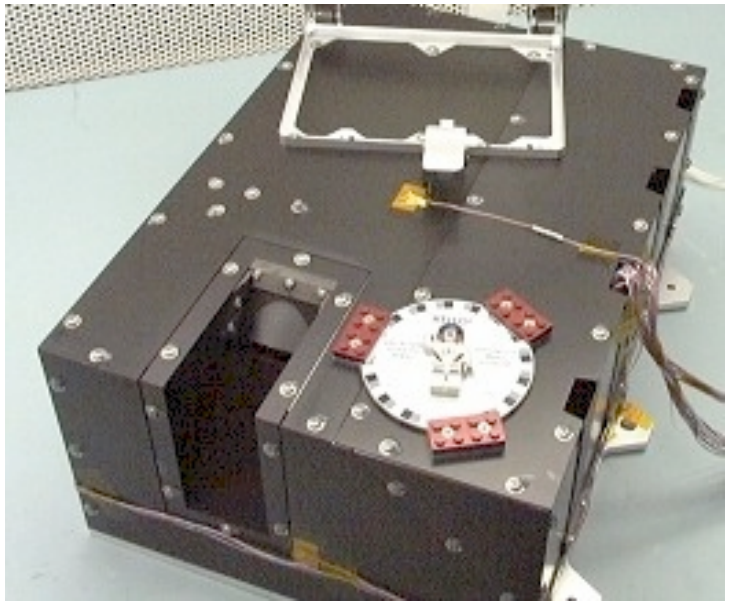
fundamental source: atmospheric H_2O_2 produced by UV light, $2x10^9$ molec cm^{-2} s^{-1}

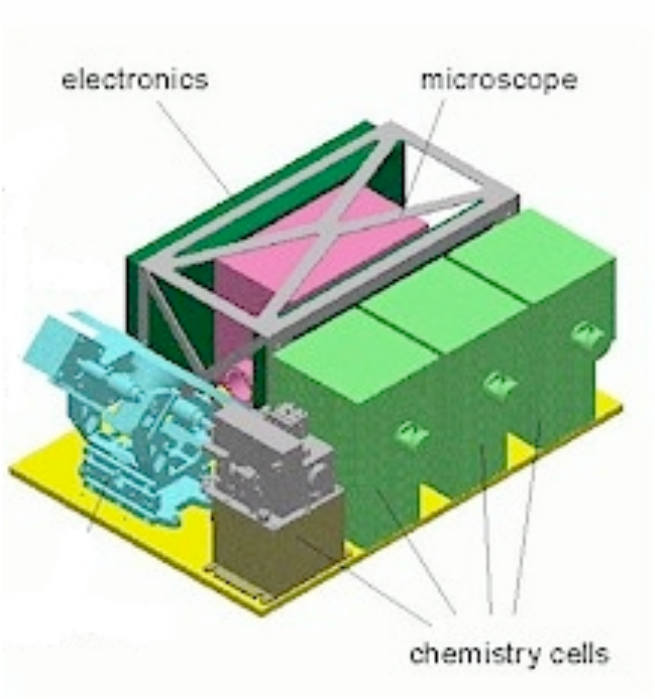
Laboratory Simulations

H_2O_2 modified TiO_2 (Quinn and Zent, 1999) is probably the best laboratory simulation todate.

Yen et al. (2000) suggested superoxide ions

Microscopy, Electrochemistry, and Conductivity Analyzer (MECA) for the Phoenix mission (2007).

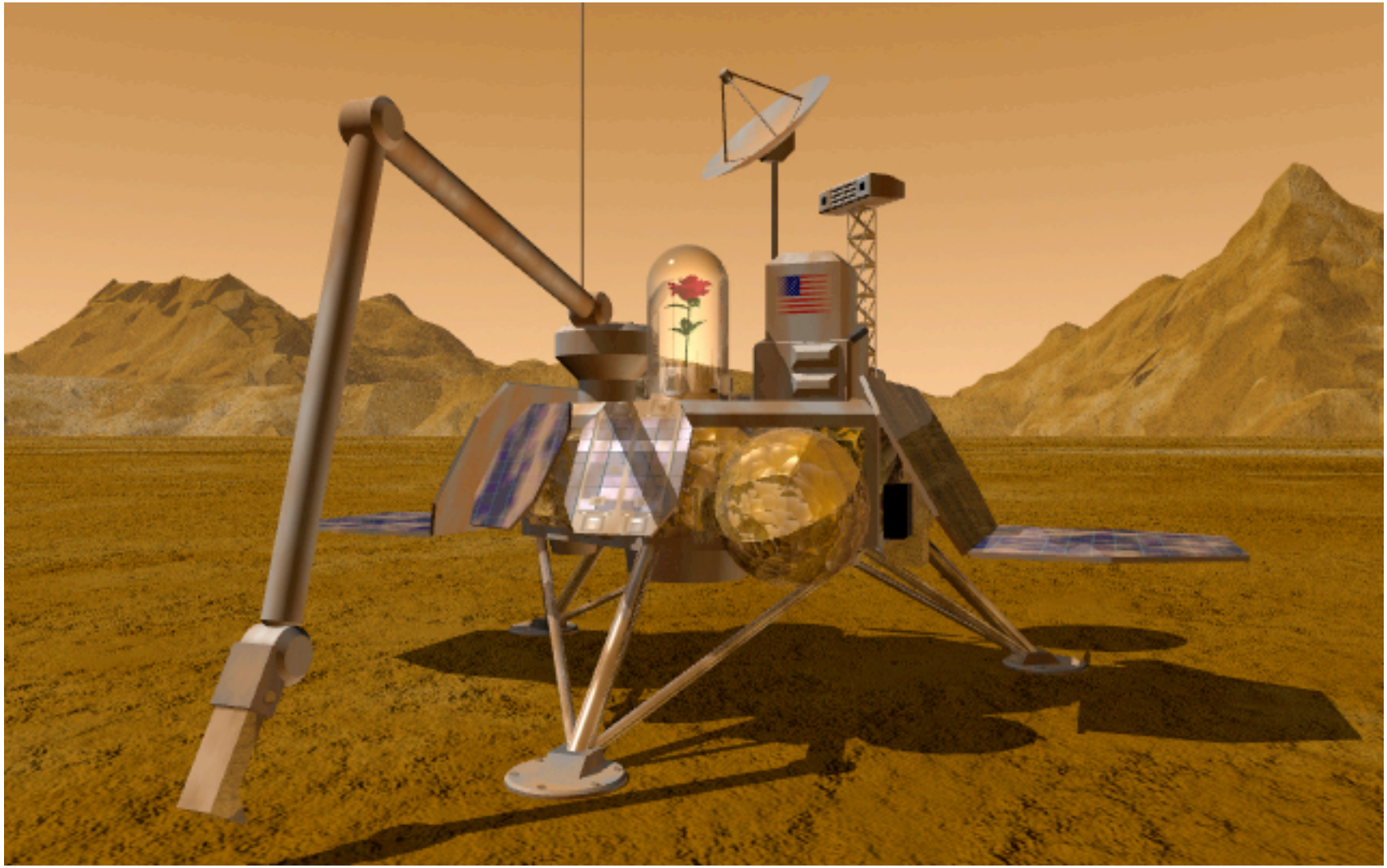




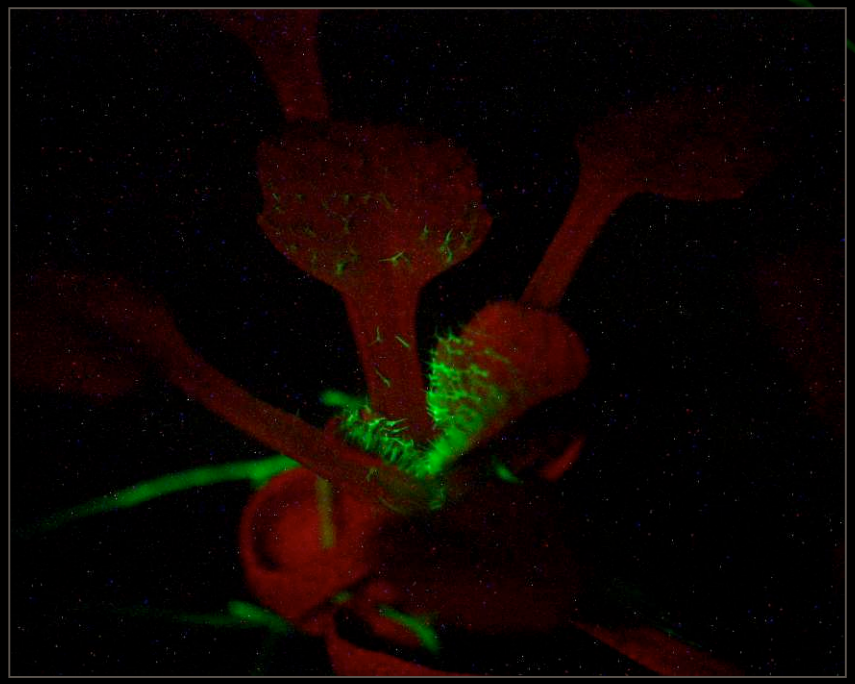
MECA comprises three main instruments:
- Wet Chemistry Laboratory consisting of four wet cells
- Optical and Atomic Force Microscopes
- Thermal and Electrical Conductivity Probe

Near-term missions

Soil toxicity based on whole organism (plant) response in the environment.



GFP – green fluorescence indicates stress perceived for that tissue



Plant expression Adh/GFP in response to hypobaric stress

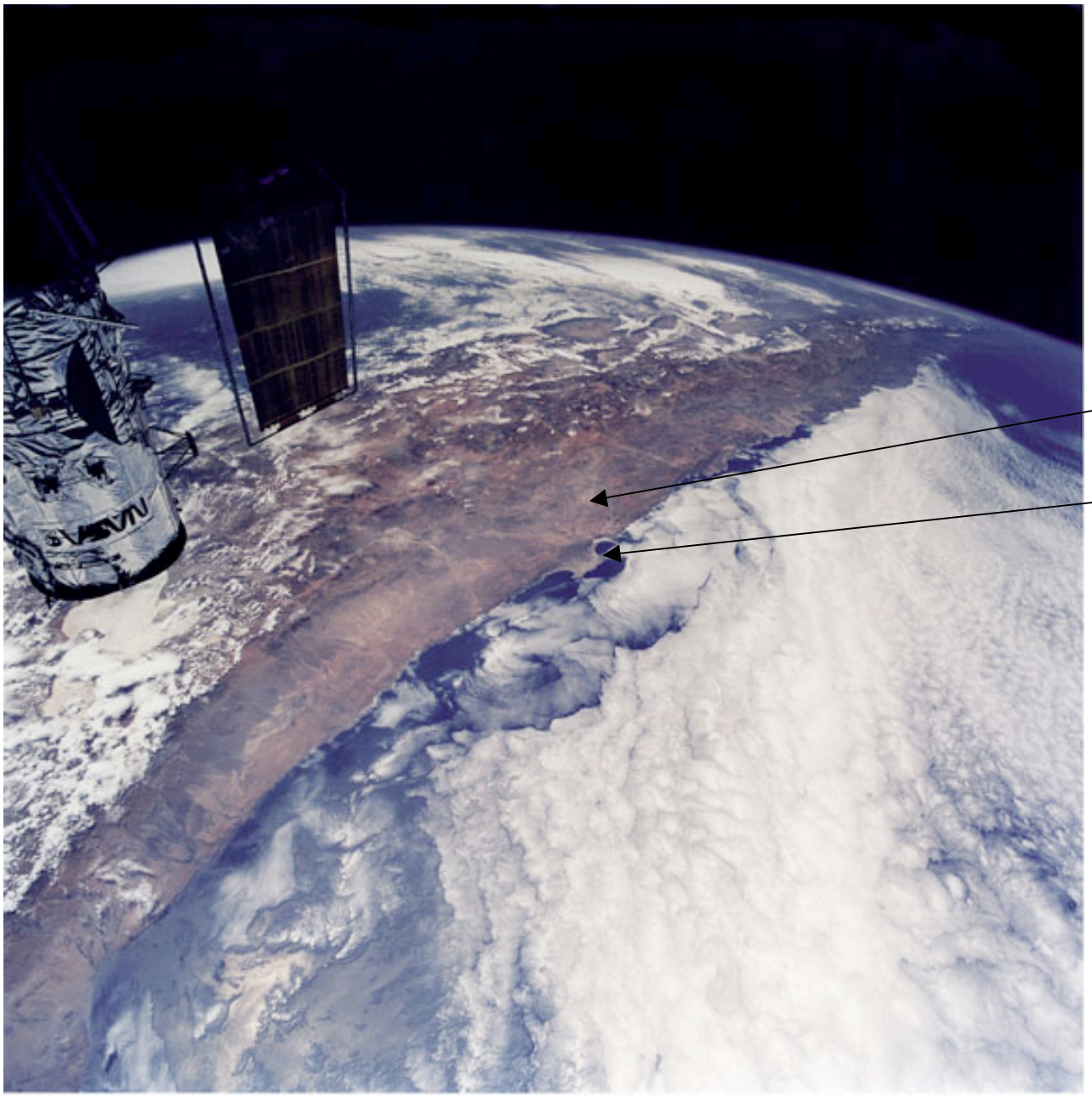
Data from R. Ferl & A.L. Paul, Univ. Fla

Grab sample return

Mars-like soils on Earth

- Laboratory analog: H_2O_2 modified TiO_2
- Geological analog: Palagonite from volcanoes in Hawaii & Iceland
- Biological & organic analog: Atacama desert soil

Palagonite in Iceland



View of Northern Chile (NASA Space Shuttle)

ESO PR Photo 24b/99 (8 June 1999)

View of Atacama
From Shuttle
with
Hubble Telescope
In the Foreground

Yungay

Antofagasta

Mars-like soils in the Atacama Desert, Chile

- Organics drop to low levels in the arid core.
- Oxidized organics increase in relative concentration
- No culturable microorganisms
- No recoverable DNA
- Abiotic consumption of organic material


"That's all Folks!"